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Transfer in Implicit Learning

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Abstract

The article describes the research, the aim of which is to discover the effect of transfer of the implicit knowledge of artificial grammar to solving of sensory-motor tasks. The article considers the role of implicit knowledge in actual cognitive activity. Forty volunteers took part in the experiment. Participants of the experiment were implicitly taught the rule of artificial grammar. At the control phase, the assignment consisted of solving the sensory-motor problem – to react to the appearance of the green or yellow circle by pressing a certain key. In the experimental group, the grammatical line always appeared before the green-colored circle was presented, and the ungrammatical line appeared before the yellow-colored circle. In the control group the color of the circle didn't depend on the grammaticality of the line. As a result, we established the considerable reduction in the reaction time in the experimental group. Thus, the transfer of the implicitly learned knowledge of artificial grammar leads to enhancement of efficiency of sensory-motor activity. The implicit rule of artificial grammar has acquired role of prime-stimulation.

Keywords: implicit knowledge, implicit learning, artificial grammar learning, sensory-motor activity, transfer effect, priming

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1. Introduction

The term 'implicit knowledge' appeared in the academic and psychological literature in the second half of the last century. The knowledge is called implicit in case it hasn't been actualized in the consciousness at the moment of carrying out of cognitive activity [8].

Experiments carried out in recent decades exposed the series of effects, reflecting the significant properties of implicit knowledge. Thus, for example, 'priming-effect' demonstrated the following: perception and problem solving may take place without consciousness. Another evidence of unconscious acquisition and use of knowledge is the 'transfer effect'. The two aforementioned effects are different. However, there is a rather strong connection between them.

'Priming' traditionally means the impact of processing of one element of information ('prime') on subsequent processing of another information (target stimulus). With the priming-effects they usually include the 'change in speed or precision of solving of a problem (perceptional, mental or mnemic) after presentation of information, related to the contents or to the background of the problem, but not in direct correlation with its purpose and requirements, as well as the rise in the probability of spontaneous reproduction of this information in appropriate conditions' [5]. It is distinguished 'positive' and 'negative' priming-effects. In the first case the presentation of the prime makes solving of the target problem easier, and in the second case it complicates the process of solving. The research of this phenomenon is carried out within the framework of cognitive, motor, motivational, emotional and other spheres [1]. In each field of research they established a large number of facts, demonstrating special characteristics of functioning of explicit and implicit systems of processing of information.

The classic example of conscious and unconscious types of priming is the research carried out by D.A. Balota. In the course of his experiment the subjects were to determine which stimuli are words and which not. The duration of presentation of stimuli was limited (2 sec.). The prime was demonstrated prior to each stimulus. To the half of the subjects the primes were demonstrated above the threshold level, to the other half – below the level of the recognition threshold. There were three types of primes: related to the target stimulus (for example, prime – *grapes*; target stimulus – *jam*), not related to the target stimulus (for example, prime – *grapes*; target stimulus – *road*) and neutral (XXXXX). The results demonstrated the following: the subjects reacted more quickly to words which were related to the preceding prime-stimulus, than to the words not related to the prime. The positive priming-effect was observed both in the case of conscious and unconscious presentation [3].

The other experimental effect, expressing the impact of implicit knowledge on solving of new cognitive problems is 'transfer'. It is distinguished 'positive' and 'negative' types of transfer. In case of 'positive transfer' information which was taken in certain conditions, enhances efficiency in another situation. In case of 'negative transfer' information which was taken in certain conditions reduces efficiency of solving problems in other conditions. Traditionally this effect is explained by the fact that the implicit knowledge has abstract form, that is, it differs from simple memorizing of specific characteristics of the stimulus material [9]. There also exist other explanatory models [4].

The main source of empirical data in the research of transfer is the method of 'artificial grammar learning'. In the experiment they may use two grammar rules and several variants of stimulus material. For example, in the A. Reber's experiment the subjects were at first asked to remember some lines (sets of consonants), then they were informed about the lines were made by using a rule, and were asked to determine which of the new lines met the requirement. However, the first group classified the lines made by using the same syntactic structure, but from another set of letters. And in the second group the lines were made from the same set of letters, but on the basis of another rule. The results demonstrated: change of the letters doesn't have a significant impact on the ability of the subjects to differentiate between grammar and non-grammar lines [9]. G. Altmann et al. discovered the possibility of transfer of an implicit knowledge also between different modalities [2].

Comparing 'priming-effect' with 'transfer effect', we may identify one fundamental difference. 'Priming-effect' is the product of implicit memory, and 'transfer effect' comes under implicit learning. Many authors point out the existence of a strong inter-relation between implicit memory and implicit learning (e.g., [6]). However, the overwhelming majority of research of these phenomena is conducted independently of each other. In the experimental research presented below which used the technique of 'artificial grammar learning', we drew on the experience, accumulated both in the sphere of implicit learning and in the course of study of implicit memory. The specific characteristic of the experimental conditions created by us is the absence of explicit directives for the use of the taken in implicit knowledge. This gives grounds to believe that the experimental effect – in case it is detected – constitutes specifically the manifestation of the impact of the implicit knowledge, about existence of which the participants hasn't been informed.

Purpose of the research: to establish whether the implicit knowledge of artificial grammar may cause the priming effect when solving sensory-motor problems. Hypothesis: the effect of transfer of implicitly learned rule of artificial grammar may be expressed in the reduction of reaction time when fulfilling sensory-motor tasks.

2. Methodology

2.1. Participants

Forty volunteers, aged from 18 to 43 years old (M = 22 years old) took part in the experiment. The whole selection was randomly differentiated into two groups (20 people each): experimental (EG) and control (CG).

2.2. Equipment and stimulus material

All experimental procedures were conducted on a personal computer, screen diagonal 15,6”. For conducting of the experiment we developed a special computer program.

In the experiment we used 40 grammar and 25 non-grammar lines, created with the help of artificial grammar which was published in the article by L. Brooks and J. Vokey [4]. 10 more lines were created by using another set of letters without a rule.

2.3. Procedure

The procedure was carried out individually with each participant.

The experiment included five phases: preliminary, learning, test, control, post-experiment interview.

At the preliminary phase the line consisting of the letters, which were formed without a rule, was demonstrated to all participants in the center of the display screen. 2 seconds later the circle of green or yellow color appeared above the line. The distance between the line and the circle equals to 1 centimeter. The circle together with the line remained on the screen for 300 msec. The task of the participant consisted of pressing the key ‘←’ as quickly as possible in case the green-colored circle appears; pressing the key ‘→’ as quickly as possible in case the yellow-colored circle appears. The participants fulfilled 10 such sensory-motor tasks. In case the participants were not able to react during 300 msec, the screen remained blank until the key was pressed. The interval between pressing and presentation of the next line lasted for 1 sec. The time of reaction of the participants was recorded, it was counted from the moment of appearance of the circle till the moment of pressing of the key.

At the phase of learning 15 grammar lines were presented one by one in the center of the screen. Prior the learning phase the participants were told that the stimulus lines had been created according to the rules, but the rules were not explained. All lines were demonstrated for 3 sec. The participants were asked to memorize and write down the lines.

During the test phase 10 grammar and 10 non-grammar lines were presented in a row in random order. These lines were created on the basis of the same artificial grammar which was used for the lines demonstrated at the learning phase. The participants were required to press as quickly as possible the key ‘←’, if they thought that the line corresponded to the rule; and to press as quickly as possible the key ‘→’, if they thought that the line didn’t correspond to the rule.

At the control phase the stimulus material was presented in the same way as at the preliminary phase, but we used 15 grammar and 15 non-grammar lines, created by using the same artificial grammar at the learning phase. Besides, in the experimental group the color of the circle depended on grammaticality of the line: the grammar line was presented before the green circle appeared; the non-grammar line preceded the appearance of the yellow circle.

The participants were not told about relationship between the color of the circle and the type of line.

In the control group the said relationship in the course of presentation of the stimulus material was absent.

The task for the participants was same as at the preliminary phase.

On completion of the experiment we conducted the post-experiment interview. The participants were asked to write which rules of positioning of letters in the lines, bigrams, trigrams they had noticed; why are the lines needed at the fourth phase.

3. Results

3.1. Subsection: Analysis of answers to the questions of post-experiment interview

At first, we conducted the analysis of the answers to the questions of post-experiment interview. We detected four participants (two persons in the EG and in the CG), who supposed that there existed the relationship between the stimuli of the control phase. Their results were excluded from further processing. The majority of the remaining participants told that they had an idea of correlation of the stimuli by the end of the control stage because of the simplicity of the task. No participant could correctly explicate the rules of artificial grammar.

3.2. Subsection: Analysis of reaction time

On the basis of the results of the test phase the participants of both groups were divided into those who effectively took in the rule of artificial grammar and those whose implicit learning was not registered. The division was made with the help of breaking down the selection as per the median of the number of correct responses (12 correct responses) (Table 1).

Table 1: Distribution of the participants on the basis of existence/absence of implicit learning.

Implicit learning	**Number of participants**	
	EG	**CG**
Existence	10 (55.56%)	14 (77.78%)
Absence	8 (44.44%)	4 (22.22%)

Prior to analysis of the time of sensory-motor reaction we conducted preparation of the results described later. We withdrew the time of reaction, which was measured in the first tests, from the series of preliminary and control phase.

In order to consider the pattern of the time of reaction at the control phase the results were divided into three parts: first third part – tests 2–10; second third part – tests 11–20; third part – tests 21–30.

In order to take into account the individual peculiarities of the participants we made the following calculations. At first, the average time of reaction at the preliminary phase was calculated for each participant separately. Secondly, on one-at-a-time basis for each test of the control phase we calculated the difference between the time of this test and the average time demonstrated at the preliminary phase. Then, we calculated the average of these differences inside each one third for each participant. Thus, the difference in the time of reaction shows for how much quicker the participants solved the problem in each one-third at the control phase in comparison with the average value of the preliminary phase: positive values mean that at the control phase the time of reaction was longer, negative values mean that the time of reaction was shorter (Figure 1).

After transformation of the results we used the three-factor ANOVA of the 2x2x3 type (2 (EG and CG) x 2 (existence/absence of implicit learning) x 3 (one-third of the control phase).

ANOVA demonstrated that the factor of implicit learning is significant in itself ($F(1; 1032) = 8.75870$; $p < 0.01$; $\eta^2 = 0.008416$), but not significant in any of interactions. This shows, that implicit learning in about the same degree influenced the time of making the decision at the control stage and in the subgroup with the 'existence' of the implicit learning and with the 'absence' thereof (Table 1). That is why further on the experimental and control groups are shown without being broken down into subgroups (Figure 1).

Results of ANOVA discovered considerable interaction between the factors 'group' and 'one-third' ($F(2; 1032) = 6.54619$; $p < 0.01$; $\eta^2 = 0.012527$).

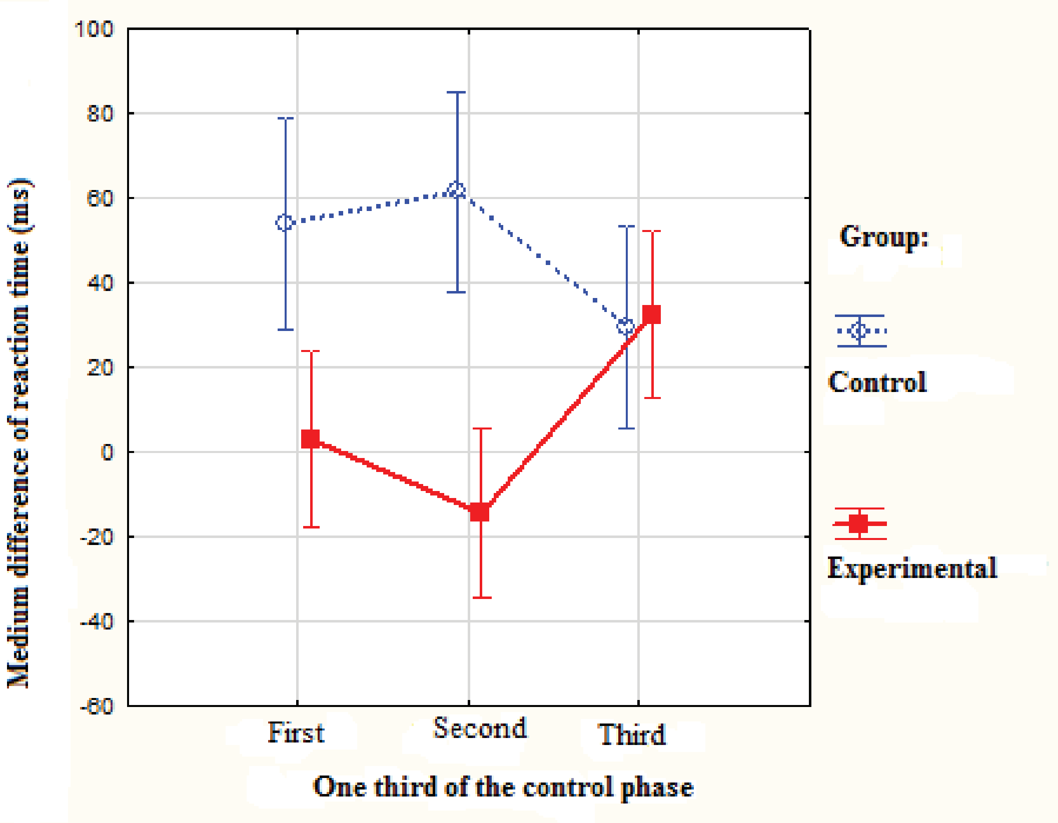

Figure 1: Medium difference of reaction time of the one-thirds of the control phase in comparison with the time observed at the preliminary phase, with confidence intervals.

4. Discussion

The processed results demonstrated the considerable interaction between the factors 'group' and 'one-third'. The dynamics of the time of the sensor-motor reaction at the control phase in the EG is significantly different from the equivalent dynamics in the CG. The time of reaction of the participants in the EG in the second one-third of the control phase is significantly shorter than in each one third of the control phase among the participants forming the CG (as per the Tukey's test: $p < 0.01$ in each of three comparisons) (Table 1, Figure 1). This allows to make the conclusion, that the participants of the EG implicitly took in the regularity in the conditions of the related presentation of stimuli. Due to this fact the sensory-motor task was performed more efficiently.

In the CG the increase in the time at the first and second one-third of the control phase in comparison with the preliminary phase, possibly, is indicative of unconscious analysis of the stimulus material.

In the last one-third of the control stage in the EG we registered significant increase in the time of reaction in comparison with the second one-third (as per the Tukey's

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test: $p < 0.01$). In its turn, in the CG, on the contrary, the time of reaction is reduced in such a way so that the results demonstrated by the EG and CG become practically equal ($p = 0.99$). This data is consistent with the replies of the research subjects to the questions of the post-experiment interview. As it was noted earlier, most of the participants confessed that because of the simplicity of the task they started thinking about the nature of relationship between the stimuli by the end of the control phase. In other words, the participants started analyzing the information consciously, which, apparently, complicated its implicit use.

Thus, we detected a certain effect of transfer of the implicitly learned the rule of artificial grammar to solving of sensory-motor tasks. Within the framework of our research the said effect is expressed in a quicker reaction to the stimuli, related to the grammaticality of the lines, namely: the participants demonstrated a significantly shorter time of relevant reactions under presentation of target stimuli, in case green circles are preceded by grammar lines and yellow circles – by non-grammar lines. The result of implicit solving of the task of classification of the lines is transferred to performance of the sensory-motor task. The transfer effect is best manifested in the second one-third of the control phase in the EG.

The observed effect is akin to the effect of semantic transfer, discovered by N.S. Kudelkina and T.A. Sviridova. They suggested that in their experiment as the result of implicit analysis of the series of inception presentations the meaning of the conscious context of the tasks ('solvable/unsolvable'), in which the stimulus was presented, is transferred to the neutral unconscious stimulus. Consequently, the stimulus which was a priori semantically neutral, acquired the properties of a prime [7].

The transfer we discovered may also be regarded as a specific positive priming-effect in the sense that after implicit analysis of the series of presentations of the first one-third of the control phase in the EG the grammar lines became primes for the green-colored circles, the non-grammar lines became primes for the yellow-colored circles, contributing to speeding up of reaction.

The logic of emergence of the priming-effect may be described in the following manner. At first the participants implicitly take in the regularity of the related presentation of the stimuli. Then the unconscious realization of the fact, that it is a grammar line that is being demonstrated, actualizes the expectation of the green circle. In its turn, this expectation suggests the existence of motor readiness to react in the corresponding way, that is, to press the key '←". Appearance of a non-grammar line actualizes the expectation of the yellow circle and of the relevant motor set.

5. Conclusions

The results obtained in the course of the conducted research in whole confirm the original hypothesis. We found the effect of transfer of the implicit knowledge of the rule of artificial grammar to the sensory-motor activity which is another type of cognitive activity, other than test classification in case of standard use of the experimental technique of 'artificial grammar learning'. In the experiment the effect manifested itself via reduction of the time of reaction to chromatic stimuli of two types, related to the grammaticality of the lines. The effect was preceded by the series of presentations. In the said series each grammatically correct line preceded the appearance of target stimuli of one type and each non-grammar line preceded the appearance of target stimuli of another type. The obtained results allow supposing that at first the participants needed to implicitly establish the type of lines and take in the regularity in accordance with which the type of the line is related to a certain target stimulus. This contributed to the enhancement of efficiency of performance of the sensory-motor task.

The established transfer is indicative of the impact of the implicit knowledge on explicit processes even in the conditions of absence of the instruction reflecting the existence of such knowledge. The participants without any instructions from the tester implicitly detected the introduced regularity of the related presentation of stimuli. Thus, implicit rule of artificial grammar acquired role of prime-stimulation.

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